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Factors Affecting Foliar Retention of Some Model Adjuvant Oil-in-Water Emulsions

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Abstract: The foliar retention of dilute oil-in-water emulsions containing three chemical types of adjuvant oil formulated either as ECs or EWs was compared in track-sprayer experiments using the water-soluble tracer, fluorescein. Although both types of emulsion enhanced tracer deposition onto water-repellant pea and barley foliage, compared with sprays containing no adjuvant, consistently better retention was achieved using the EW emulsions, irrespective of oil composition. On young plants, fluorescein retention using the EC emulsifier alone was similar to that from the corresponding emulsions. However, on older plants, retention from EC emulsions was superior to that from the EC emulsifier. Comparable effects were not observed using the EW stabiliser, which had little influence on the efficiency of spray deposition. The retention behaviour of the various oil-based adjuvants is discussed in relation to their effects on spray quality and their formulation ingredients.

Pestic. Sci., **54**, 000–000 (1998)

Key words: adjuvant oils; oil-in-water emulsions; spray retention; spray quality

1 Introduction

It is well known that oil-based adjuvants can increase the biological activity of many foliage-applied herbicides and of some fungicide formulations. Although this beneficial effect is generally attributed to increased pesticide uptake,[1] the precise mechanisms of action of these adjuvant oil-in-water emulsions remain poorly understood. In particular, their influence on the efficiency of spray delivery has been largely overlooked.

In the present work, we have measured the foliar retention of oil-in-water emulsions containing three chemical types of adjuvant oil, prepared either as emulsifiable concentrates (ECs), using a surfactant emulsifier, or as concentrated oil-in-water emulsions (EWs) formulated with a polymeric stabiliser. Retention performance was also examined in relation to spray quality data obtained using a phase-Doppler particle analyser (PDPA).

2 Methods

Peas (*Pisum sativum* L. cv. Meteor; three plants per pot) and barley (*Hordeum vulgare* L. cv. Triumph; 10 plants per pot) were raised from seed in pots of compost and maintained in a controlled environment room. Spray applications were made 18 or 22 days (pea) and 10 or 15 days (barley) after sowing. Three candidate oils, Light Liquid Paraffin B.P. (LLP) (mineral oil ex Thornton Ross, UK), soya oil (S) (refined vegetable oil ex Seatons, UK) and methyl soyate (MS) (fatty acid methyl ester, Edenor ME Sj, ex Henkel, Germany) were prepared as ECs with a surfactant blend of Ethylans D253 + C12AH (Akcros Chemicals UK; 1 + 1 by weight; 100 g litre^{-1}) or as EWs with a polymeric stabiliser (Mowiol 3-83 ex Clariant, Germany; 24 g litre^{-1}). Diluted ECs and EWs containing 5–20 g oil litre^{-1}, corresponding rates of emulsifier or stabiliser alone, a nonylphenol surfactant (NP10EO, Agral, ex Zeneca, UK) and a solvent-based bench-mark (acetone + water 1 + 1 by volume), were applied to target foliage at *c.* 200 litre ha^{-1} using a laboratory track-sprayer fitted with an even-spray nozzle. Sodium fluorescein (0·05 g litre^{-1}) was included in all spray solutions; tracer recoveries from sprayed foliage were quantified by spectrofluorimetry and expressed as deposits per unit emulsion (DUE) values, *viz.* ng fluorescein per g dry weight foliage per g fluorescein applied per ha.

3 Results and discussion

Addition of oil ECs and EWs to aqueous sprays enhanced fluorescein deposition on water-repellent pea

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Contract/grant sponsor: Biotechnology and Biological Sciences Research Council.
Contract/grant sponsor: AgroEvo UK Ltd.

and barley foliage significantly, compared with water alone (Table 1). However, EW emulsions were always retained much better than the corresponding emulsions from ECs, at all concentrations examined. For example, the DUE value for MS EW (10 g litre^{-1}) on 18-day-old pea foliage was 851 compared with 251 for the corresponding EC. On small pea and barley plants, retention of the EC emulsions (mean DUE 319 and 164 for pea and barley, respectively) was similar to that of the emulsifier alone (DUE 305 and 152 for pea and barley, respectively), when sprayed at concentrations equivalent to that in diluted ECs. On the other hand, fluorescein retention with the emulsifier (DUE 164 and 224 for pea and barley, respectively) was inferior to that from the emulsions (mean DUE 278 and 682 pea and barley, respectively), when sprayed on larger plants. Retention enhancements observed with EC emulsions or their emulsifier were less than those obtained using NP10EO (2 g litre^{-1}) or aqueous acetone.

In contrast, emulsions formed by dilution of oil EWs always enhanced retention much more than the equivalent concentration of the stabiliser applied alone, irrespective of target species or size. For example, applications with the stabiliser to 10-day-old barley gave a DUE value of 102, similar to that of water (DUE 122); the three EWs at 10 g litre^{-1} gave a mean DUE value of 300 on this target (Table 1). The retention performance of EW emulsions was as good as those of the surfactant and organic solvent bench-marks on 18-day-old pea foliage.

In-flight PDPA measurements of the spray cloud at the position corresponding to impact with target foliage revealed that addition of all oil ECs tested, as well as their emulsifier, increased droplet volume median diameters (VMDs) (244–269 μm) considerably in comparison with water (217 μm) (Fig. 1), with corresponding decreases in the small droplet component (SDC, percentage of spray volume with droplets <100 μm in diameter) from 6·1% for water to 2·0–3·2%. This phenomenon has already been reported for several commercial adjuvant oil ECs by Butler Ellis *et al.*[2] Although the EW stabiliser had little effect on spray quality compared with water, addition of the three oil EWs also increased VMDs (302–534 μm) and decreased SDCs (0·8–2·4%) substantially. In marked contrast, the surfactant, NP10EO decreased VMDs to 195 μm and increased SDCs to 10·6%.

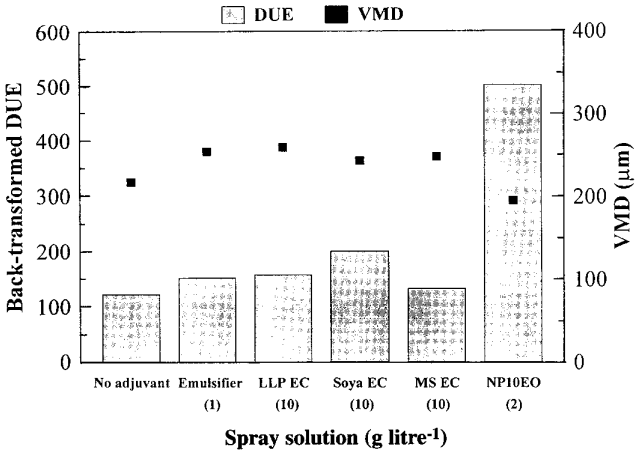

Fig. 1. Relationships between spray retention (DUE) on 10-day-old barley and droplet VMDs for three oil EC emulsions, the EC emulsifier and a surfactant.

TABLE 1
Effects of Diluted Oil ECs, Oil EWs and their Co-formulants on Spray Retention of Fluorescein by Pea and Barley Foliage

Spray solution (g litre^{-1})		*Mean DUE values*[a]			
		Pea		*Barley*	
		18-day-old	*22-day-old*	*10-day-old*	*15-day-old*
No adjuvant		4·68 (108)	4·44 (85)	4·80 (122)	5·12 (167)
EC emulsifier	(1)	5·72 (305)	5·10 (164)	5·02 (152)	5·41 (224)
LLP EC	(10)	5·58 (266)	5·87 (353)	5·06 (158)	6·45 (634)
Soya EC	(10)	6·02 (412)	5·64 (280)	5·30 (201)	6·50 (665)
Methyl soyate EC	(10)	5·53 (253)	5·30 (200)	4·89 (133)	6·62 (746)
EW stabiliser	(0·6)	5·32 (205)	5·13 (168)	4·63 (102)	5·64 (280)
LLP EW	(10)	6·62 (752)	6·24 (512)	5·79 (326)	6·86 (952)
Soya EW	(10)	6·55 (698)	6·61 (741)	5·53 (252)	6·49 (660)
Methyl soyate EW	(10)	6·75 (851)	6·27 (528)	5·78 (323)	6·50 (662)
NP10EO	(2)	6·08 (439)	6·10 (446)	6·22 (502)	6·39 (596)
Acetone	(500)	6·60 (738)	6·86 (951)	6·83 (926)	6·91 (1004)

[a] Log_n-transformed values for statistical analysis; back-transformed values in parentheses. 18-day-old pea SED, 0·17 (96 df); 22-day-old pea SED, 0·14 (96 df); 10-day-old barley SED, 0·28 (96 df), 15-day-old barley SED, 0·11 (96 df).

There was good agreement between spray cloud characteristics and the retention behaviour of oil ECs and EC emulsifier on small pea and barley plants (Fig. 1). Larger droplets would be expected to be retained less well than smaller ones, explaining the much better deposition of fluorescein achieved with the surfactant solution. However, changes in spray quality did not account for the discrepancy between EC emulsions and EC emulsifier observed on larger target plants or for the marked differences in retention between EC and EW emulsions containing the same oil, irrespective of target species and size. These effects indicate that there is a complex physicochemical interaction between oil and co-formulant when emulsion droplets impact on foliage. Nevertheless, in all of our experiments, oil composition appeared to have only a minor influence on the efficiency of spray delivery of either EC or EW emulsions.

Acknowledgements

KJH is grateful for the award of an Industrial CASE Studentship from the Biotechnology and Biological Sciences Research Council of the UK and AgrEvo UK Ltd. We thank Ann Hayes for skilful technical assistance and Nigel Western for PDPA measurements.

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